WHAT IS CLAIMED IS:

1. A method for pseudo-physically modeling the erosion rate of the surface of a workpiece being polished by a stack of polishing pads including a base pad and a top pad, said method comprising the steps of:

a) determining the contact force between the surface of the workpiece being polished and the stack of polishing pads by:

1) equating the base pad to a first abstract mathematical spring having compressibility factor k_1;

2) equating the top pad to a second abstract mathematical spring having compressibility factor k_2;

3) said first and second abstract mathematical springs being connected together in series;

4) determining the force on the stack of polishing pads by determining the combined deflection of the base pad and the top pad;

b) equating the force on the stack of polishing pads to the force on the surface of the workpiece being polished;

c) determining the erosion rate of the surface of the workpiece being polished by multiplying the force on the surface of the workpiece being polished by a predetermined constant.

2. The method for pseudo-physically modeling as defined in Claim 1 wherein a compressibility factor k_1 is selected for a predetermined erosion rate of the surface of the workpiece.

3.   The method for pseudo-physically modeling as defined in Claim 1 wherein a compressibility factor k_2 is selected for a predetermined erosion rate of the surface of the workpiece.

5

4.   The method for pseudo-physically modeling as defined in Claim 1 wherein said force on the surface of the workpiece being polished is selected for a predetermined erosion rate of the surface of the

10   workpiece.

5.   The method for pseudo-physically modeling as defined in Claim 1 wherein the force on the stack of polishing pads is obtained by dividing the stack of

15   polishing pads and the surface of the workpiece being polished into a plurality of individual nodes i.

6.   The method for pseudo-physically modeling as defined in Claim 5 wherein each node i of the stack of

20   polishing pads has an adjacent node j.

7.   The method for pseudo-physically modeling as defined in Claim 6 wherein:

the spring force on a node *i* in the base pad is the product of said compressibility factor k_1, the deflection
5   of the base pad, and the area of said node *i*, and

wherein the spring force on a node *i* in the top pad is the product of said compressibility factor k_2, the deflection of the top pad, the length of contact between node *i* and an adjacent node *j* and the thickness of the
10 top pad.

8.   The method for pseudo-physically modeling as defined in Claim 6 wherein:

the force F_{1i} from a base pad node is computed using
15 the formula:

$$F_{li} = -rk_l \left(p_o - z_{pi} \right) dx_i dy_i$$

where $-rk_l$ is a Hookean spring constant

$p_o - z_{pi}$ is the amount of deflection of the
20 base pad

$dx_l \ dy_l$ is the size of the node.

9.   The method for pseudo-physically modeling as defined in Claim 8 wherein:

the force F_{2ij} from a top pad node is computed using the formula:

5

$$F_{2ij} = rk_2 \ (z_{pj} - z_{pi}) \ l_{ij} \ h$$

where rk_2 is a Hookean spring constant

$(z_{pj} - z_{pi})$ is the amount of deflection of the top pad

10        $l_{ti} \ h$ is the size of the node.

10.   The method for pseudo-physically modeling as defined in Claim 9 wherein:

the nodal contact force is computed using the

15   formula:

$$f_i = F_{li} + \sum_{j=1}^{m_j} F_{2[i][mi(j)]}$$

11. A method for simulating the performance of a
system for chemical mechanical polishing of the surface
of a workpiece by a moving pad, said method comprising
the steps of:

5   a)   modeling the surface of the workpiece by a
collection of nodes located in a plane w, each of said
wafer nodes having a location defined by the Cartesian
coordinates x_{wi}, y_{wi}, z_{wi};

         b)   modeling the surface of the moving pad by a
10   collection of nodes located in a plane P parallel to said
plane w, each of said pad nodes having a location defined
by the Cartesian coordinates x_{wi}, y_{wi}, z_{pi};

         c)   establishing a first linear spring force at
each of said pad nodes, said first linear spring force
15   being expressed as a function of the deflection of the
pad;

         d)   establishing a second linear spring force on
each of said pad nodes as a function of the connection
distance of each pad node to an adjacent pad node;

20   e)   summing said first and second linear spring
forces to determine the total force on each pad node;

         f)   determining the rate of change of a wafer node
coordinate z_{wi} during small time segments as a function of
the force applied by each pad node on a corresponding
25   workpiece node;

         g)   determining the deformation of each of said pad
nodes during said small time segment, by the change in
location of said pad node Cartesian coordinate z_{pi} caused
by the total force on each of said pad nodes on the
30   surface of the workpiece;

h) determining the erosion of each node on the workpiece surface in said small time segment by the change in location of each of said workpiece node Cartesian coordinate z_{wi}.

5

12. A pseudo-physical modeling method for use with
a chemical mechanical polishing (CMP) system having a
carrier element configured to hold a workpiece against a
stack of polishing pads including a base pad and a top
5   pad during a CMP procedure, said modeling method
comprising the steps of:
       a)   obtaining an initial feature scale pattern
associated with said workpiece;
       b)   acquiring a deformation model of a polishing
10   element associated with said CMP system;
       c)   said deformation model including the steps of:
       1)   equating the base pad of a first abstract
mathematical spring;
       2)   equating the top pad to a second abstract
15   mathematical spring connected in series with said
first abstract mathematical spring; and
       d)   performing a modeling routine to thereby obtain
a feature scale simulation result for said workpiece,
said feature scale simulation result being responsive to
20   said initial feature scale pattern and to said
deformation model.

       13. The pseudo-physical modeling method as defined
in Claim 12, wherein:
25   said initial feature scale pattern is defined
at a plurality of nodes; and
       said deformation model utilizes said first and
second abstract mathematical springs associated with one
of said nodes.

30

14. The pseudo-physical modeling method as defined in Claim 13, wherein:

said performing step performs said modeling routine to generate a simulated contact profile for said polishing element in relation to a current simulated feature scale pattern, said simulated contact profile being responsive to a current state of said first and second abstract mathematical springs; and

said performing step performs said modeling routine to simulate erosion of said workpiece in response to said simulated contact profile to thereby obtain said feature scale simulation result.

15. The pseudo-physical modeling method as defined in Claim 13, wherein:

said performing step performs said modeling routine to determine a localized force profile associated with said polishing element in relation to a current simulated feature scale pattern; and

said performing step performs said modeling routine to stimulate erosion of said workpiece in response to said localized force profile to thereby obtain said feature scale simulation result.

16. A pseudo-physical modeling method as defined in Claim 13, wherein said first and second abstract mathematical springs are associated with adjacent nodes.

17.   The pseudo-physical modeling method as defined
in Claim 12 further comprising the step of:
    obtaining a plurality of CMP process parameters
associated with said CMP procedure, wherein said feature
5   scale simulation result is further responsive to said CMP
process parameters.

18.   The pseudo-physical modeling method as defined
in Claim 12 wherein said performing step comprises the
10   step of estimating erosion of said workpiece in response
to a simulated local force associated with said
deformation model.

19.   A pseudo-physical modeling system for use with a chemical mechanical polishing (CMP) system configured to perform a CMP procedure upon a workpiece with a polishing pad stack having a base pad and a top pad, said

5   pseudo-physical modeling system comprising:

    means for receiving CMP data associated with said CMP procedure;

    said means for receiving CMP data being configured to receive both an initial feature scale

10   pattern associated with the workpiece and a deformation model of a polishing element associated with the CMP system,

    said deformation model including:

    means for equating the base pad to a first

15   abstract mathematical spring;

    means for equating the top pad to a second abstract mathematical spring connected in series with said first abstract mathematical spring;

    a processor configured to perform a modeling

20   routine to thereby obtain a wafer scale simulation result and a feature scale simulation result for said workpiece, each of said wafer scale simulation result and said feature scale simulation result being responsive to said CMP data; and

25   said processor being further configured to obtain said feature scale simulation result in response to said initial feature scale pattern and to said deformation model;

    means for comparing at least one of said wafer

30   scale simulation result and said feature scale simulation

result to an empirical CMP result associated with said
CMP procedure to thereby obtain a simulation error.

20.   A pseudo-physical modeling system for use with a chemical mechanical polishing (CMP) system configured to perform a CMP procedure upon a workpiece with a polishing pad stack having a base pad and a top pad, said

5   pseudo-physical modeling system comprising:

means for receiving CMP data being configured to receive both an initial film thickness profile associated with said workpiece and a deformation model of a polishing element associated with the CMP system;

10   said deformation model including:

means for equating the base pad to a first abstract mathematical spring;

means for equating the top pad to a second abstract mathematical spring connected in series with

15   said first abstract mathematical spring;

a processor configured to perform a modeling routine to thereby obtain a wafer scale simulation result and a feature scale simulation result for the surface of the workpiece, each of said wafer scale simulation result

20   and said feature scale simulation result being responsive to CMP data;

said process being configured to obtain said wafer scale simulation result in response to said initial film thickness and to said deformation model;

25   means for comparing at least one of said wafer scale simulation result and said feature scale simulation result to an empirical CMP result associated with said CMP procedure to thereby obtain a simulation error.

21. A system for the chemical mechanical polishing
of the surface of a workpiece comprising:

a rotating pad stack, said rotating pad stack
including a base pad and a top pad;

5   means for positioning the workpiece against the
rotating pad stack;

means for controlling the operation of the
chemical mechanical polishing system, said means for
controlling including:

10   means for receiving CMP data being configured
to receive both an initial feature scale pattern
associated with the workpiece and a deformation model of
a polishing element associated with the CMP system;

said deformation model including:

15   means for equating the base pad to a first
abstract mathematical spring;

means for equating the top pad to a second
abstract mathematical spring connected in series with
said first abstract mathematical spring;

20   a processor configured to perform a modeling
routine to thereby obtain a wafer scale simulation result
and a feature scale simulation result for the surface of
the workpiece, each of said wafer scale simulation result
and said feature scale simulation result being responsive

25   to CMP data;

said process being configured to obtain said
wafer scale simulation result in response to said initial
feature scale pattern and to said deformation model;

means for comprising at least one of said wafer

30   scale simulation result and said feature scale simulation

result to an empirical CMP result associated with said
CMP procedure to thereby obtain a simulation error.

22. A system for the chemical mechanical polishing
of the surface of a workpiece comprising:

a rotating pad stack, said rotating pad stack
including a base pad and a top pad;

5   means for positioning the workpiece against the
rotating pad stack;

means for controlling the operation of the chemical
mechanical polishing system, said means for controlling
including:

10   means for receiving CMP data being configured to
receive both an initial film thickness profile associated
with the workpiece and a deformation model of a polishing
element associated with the CMP system;

said deformation model including:

15   means for equating the base pad to a first
abstract mathematical spring;

means for equating the top pad to a second
abstract mathematical spring connected in series with
said first abstract mathematical spring;

20   a processor configured to perform a modeling routine
to thereby obtain a wafer scale simulation result and a
feature scale simulation result for the surface of the
workpiece, each of said wafer scale simulation result and
said feature scale simulation result being responsive to

25   CMP data;

said processor being configured to obtain said wafer
scale simulation result in response to said initial film
thickness and to said deformation model;

means for comparing at least one of said wafer scale

30   simulation result and said feature scale simulation

result to an empirical CMP result associated with said
CMP procedure to thereby obtain a simulation error.

23.   A pseudo-physical modeling method for use with a chemical mechanical polishing (CMP) system, said pseudo-physical modeling method comprising the steps of:

a)   obtaining a plurality of CMP process parameters

5   associated with a CMP procedure to be performed upon the surface of a workpiece;

b)   performing a modeling routine to thereby obtain a wafer scale simulation result and a feature scale simulation result for said surface of a workpiece, each

10   of said wafer scale simulation result and said feature scale simulation result being responsive to said CMP process parameters; and

c)   producing an output indicative of at least one of said wafer scale simulation result and said feature

15   scale simulation result;

d)   obtaining an initial feature scale pattern associated with said surface of said workpiece;

e)   acquiring a deformation model of a polishing pad stack having a base pad and a top pad associated with

20   said CMP system;

said deformation model including the steps of:

equating said base pad to a first abstract mathematical spring;

equating said top pad to a second abstract

25   mathematical spring connected in series to said first abstract mathematical spring; and

wherein said performing step obtains said feature scale simulation result in response to said initial feature scale pattern and to said deformation model.

30

24. The pseudo-physical modeling method as defined in Claim 23, wherein:

said wafer scale simulation result comprises a film thickness profile; and

5   said feature scale simulation result comprises a feature pattern profile.

25. The pseudo-physical modeling method as defined in Claim 24, wherein:

10   said film thickness profile includes global wafer uniformity information; and

said feature pattern profile includes local surface planarization information.

15   26. The pseudo-physical modeling method as defined in Claim 23, further including the steps of:

a)   obtaining, prior to said performing step, an indicator of the relative importance of global wafer uniformity versus local die planarization for said

20   workpiece; and

b)   optimizing said CMP process parameters in response to said indicator to thereby produce a CMP data for use during an optimized CMP procedure.

25   27. The pseudo-physical modeling method as defined in Claim 23 further including the steps of:

a)   initializing a modeling parameter associated with said modeling routine;

b)   conducting said CMP procedure to obtain an

30   empirical CMP result;

c)   comparing at least one of said wafer scale simulation result and said feature scale simulation result to said empirical CMP result; and

d)   adjusting said modeling parameter in response
5   to said comparing step.

28.   The pseudo-physical modeling method as defined in Claim 27 wherein said empirical CMP result includes a wafer scale empirical CMP result, said modeling method
10 further including the steps of:

a)   comparing said wafer scale simulation result to said wafer scale empirical CMP result; and

b)   optimizing said modeling parameter such that an error between said feature scale simulation result and
15 said feature scale empirical CMP result is substantially minimized.

29.   The pseudo-physical modeling method as defined in Claim 27 wherein said obtaining, performing,
20 producing, initializing, conducting, comparing, and adjusting steps are performed for an existing CMP system, and wherein said method further includes the steps of:

a)   varying at least one of said CMP process parameters to thereby define an updated CMP process
25 parameter set; and

b)   thereafter repeating said performing step to thereby obtain a second wafer scale simulation result and a second feature simulation result for a theoretical CMP system, each of said second wafer scale simulation result
30 and said second feature scale simulation result being responsive to said updated CMP process parameter set.

30. The pseudo-physical modeling method as defined in Claim 23, wherein said method further includes the step of obtaining an initial feature scale pattern

5 associated with said workpiece and said performing step is responsive to said initial feature scale pattern.

31. The pseudo-physical modeling method as defined in Claim 30, further including the steps of:

10 a) initializing a modeling parameter associated with said modeling routine; and

b) optimizing said modeling parameter in response to said initial feature scale pattern.

15 32. The pseudo-physical modeling method as defined in Claim 23, wherein said method further includes the step of obtaining an initial film thickness profile associated with said workpiece and said performing step is responsive to said initial film thickness profile.

20

33. The pseudo-physical modeling method as defined in Claim 32, further including the steps of:

a) initializing a modeling parameter associated with said modeling routine; and

25 b) optimizing said modeling parameter in response to said initial film thickness profile.